PIER Energy-Related Environmental Research
Environmental Impacts of Energy Generation, Distribution and Use

A Pilot Study of Trace Metal Mobility During Combustion of Biomass Fuels

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Contractor: University of California, Davis
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The Issue

The use of biomass fuels for power production leads to atmospheric emissions and produces solid wastes that concentrate metals and other elements from the original feedstock. However, little information exists on trace metal mobility and concentrations in the combustion by-products from biomass-fueled power plants. Such information is central to the utilization of ash waste products as well as to environmental monitoring and protection.

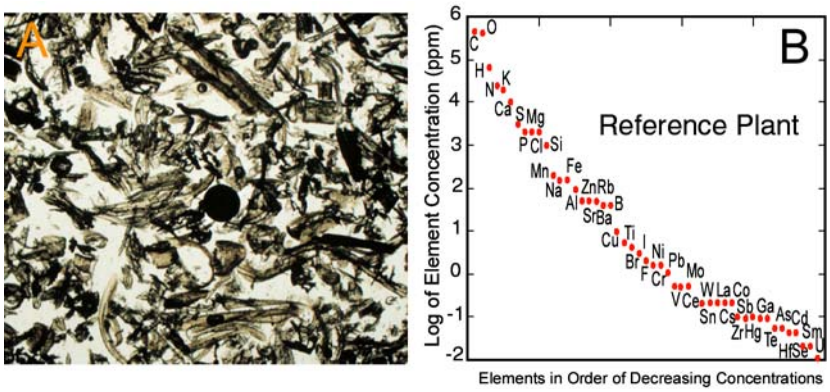

Figure 1. (A) Rice straw ash produced by firing at 525°C (977°F). (B) Reference plant material with log-scale concentration of elements (parts per million) arranged in order of decreasing concentration.

The need for this information is expected to grow. If biomass fuel consumption increases as forecasted, the total volume of by-products and waste will also significantly increase, resulting in even stronger pressures on the power industry to find alternative uses and/or safe storage facilities for the by-products of biomass combustion. Additionally, the adoption of advanced conversion technologies for biomass under different reaction conditions than employed in direct combustion systems requires prior knowledge of the content of trace elements in biomass as well as knowledge of their fate during conversion.

Project Description

This study will determine the trace element concentrations in three temperature-controlled series of ashes produced from common biomass materials (wood, rice straw, and wheat straw) in oxidizing atmospheres. A supporting study will analyze the ash products from a commercial

operating biomass-fueled power plant. The trace elements to be determined include, but are not limited to, the halogens (Cl, F), the alkalis (Be, Rb, Cs, Sr, Ba), the transitional metals (Ti, Cr, Mn, Fe, Co, Cu, Zn), the rare earth elements (La, Ce, Nb, Sm, Eu, Lu), and the heavy metals (Hg, Pb, As, Se, Sb, Cd). Other detectable trace elements will be analyzed as well. Figure 1 shows an example of a rice straw ash together with the composition of reference plant, including about 50 elements from oxygen (O) to uranium (U).

The project will be conducted at the University of California at Davis involving the Department of Geology, the Department of Biological and Agricultural Engineering, the Interdisciplinary Center for Plasma Mass Spectrometry, and the McClellan Nuclear Radiation Center (MNRC). The analytical techniques will principally include inductively coupled plasma–mass spectrometry (ICP-MS), instrumental neutron activation analyses (INAA), and X-ray fluorescence analyses (XRF).

The study will (1) provide a practical analytical protocol for analyzing biomass ash using techniques readily available to governmental and industrial laboratories, (2) determine the loss or enrichment of trace elements in representative fuel ashes as a function of temperature from 525°C (977°F) to near the melting range, (3) formulate numerical tools that allow the fate of trace elements to be predicted during biomass combustion, (4) provide a first-order insight into the trace element compositions of actual ash produced by an operating power plant, and (5) establish basic knowledge regarding the behavior of trace elements in common, relatively clean biomass fuels; such knowledge is required for future testing of trace element behavior in fuel blends incorporating other urban and agricultural waste products.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Providing environmentally sound energy.** Biomass is a renewable domestic fuel source with no sulfur emissions and dramatically lower nitrogen emissions than fossil fuels. Biomass can thus decrease acid rain and smog when used instead of fossil fuels. Net carbon emissions can be reduced, as the emitted carbon can be removed from the atmosphere by growing more biomass. This project will yield basic information that is critical to the responsible use of biomass for power generation.

- **Resolving the environmental effects of energy production.** This research will enhance state regulatory monitoring of compliance with solid waste disposal standards. Results will also benefit policy analysts and power producers by allowing prediction of trace element baselines in ash waste as new biomass materials, such as those from phytoremediation of impaired soils, are introduced into the fuel mix. Knowledge of potential leachable trace elements and their concentrations in biomass ash is necessary for planning and designing short- and long-term storage and disposal facilities as well as for developing alternative utilization strategies. For example, better knowledge of the trace elements in biomass ash can result in a better understanding of the beneficial value of ash by-products as soil fertilizers, potentially increasing the use of biomass ash and reducing the need for its disposal in landfill.

Final Report

PIER-EA staff intend to post the final report on the Energy Commission website in fall 2007 and will list the website link here.

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